



American College of
Emergency Physicians®

ADVANCING EMERGENCY CARE 

POLICY STATEMENT

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Point-of-Care Ultrasonography by Pediatric Emergency Medicine Physicians

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the Society of Academic
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the World Interactive
Network Focused on Critical
Ultrasound

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the American Academy of Pediatrics, the Society of Academic Emergency Medicine, and
World Interactive Network Focused on Critical Ultrasound*

ABSTRACT. Point-of-care ultrasonography is increasingly being used to facilitate accurate and timely diagnoses and to guide procedures. It is important for pediatric emergency medicine physicians caring for patients in the emergency department to receive adequate and continued point-of-care ultrasonography training for those indications used in their practice setting. Emergency departments should have credentialing and quality assurance programs. Pediatric emergency medicine fellowships should provide appropriate training to physician trainees. Hospitals should provide privileges to physicians who demonstrate competency in point-of-care ultrasonography. Ongoing research will provide the necessary measures to define the optimal training and competency assessment standards. Requirements for credentialing and hospital privileges will vary and will be specific to individual departments and hospitals.

Key words: ultrasound, ultrasonography, point of care, emergency department, imaging.

ABBREVIATIONS: US, ultrasonography; ED, emergency department; ACEP, American College of Emergency Physicians; PEM, pediatric emergency medicine; CT, computed tomography.

Point-of-care ultrasonography (US) is a focused ultrasonography performed and interpreted at the patient's bedside by a health care provider in conjunction with his/her clinical examination. Point-of-care US can expedite clinical decision making, direct follow-up diagnostic imaging, aid in procedural guidance and improve patient satisfaction.¹⁻⁶ Point-of-care US is focused to answer specific yes/no questions in real-time. The point-of-care US examination has important qualities as an imaging modality. There is no need to transport a patient outside of the emergency department (ED), examinations can be performed at all hours, examinations may be repeated,

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and there is no ionizing radiation exposure. Moreover, it may help direct further evaluation so as to avoid unnecessary and costly testing.

Clinician-performed US has been used and accepted since the 1960s, when obstetricians and cardiologists first adopted the technology. Use of US by those specialists is endorsed by various professional radiology organizations.^{7,8} At present, nonphysician providers, such as nurses and prehospital care workers, are also using point-of-care US as a part of their practice.⁹⁻¹⁷

HISTORY OF EMERGENCY PHYSICIAN POINT-OF-CARE ULTRASONOGRAPHY

In 1990, the American College of Emergency Physicians (ACEP) published a position statement supporting the performance of US by appropriately trained emergency physicians.¹⁸ The next year, the Society of Academic Emergency Medicine endorsed that statement and called for a training curriculum, which Mateer and colleagues published in 1994.¹⁹ By 1996, the published emergency medicine core content included point-of-care US for residency graduates.²⁰ With the passage of the American Medical Association Resolution 802 and policy H-230.960 in 1999 “recommending hospital [privileging] committees recognize specialty-specific guidelines for US credentialing decisions,”^{21,22} emergency physicians were given full responsibility for developing the guidelines of their field. By 2001, the Accreditation Council for Graduate Medical Education mandated that all emergency medicine residents attain competency in the use of point-of-care US, and the ACEP published the first emergency ultrasonography guidelines.²³ In 2008, the ACEP published an update to the original guidelines,²⁴ thereby establishing the most comprehensive specialty-specific training and practice to date.²⁵ Subsequently, the Society of Academic Emergency Medicine, the Council of Emergency Medicine Residency Directors, and the American Institute of Ultrasound in Medicine officially recognized that document.^{26, 27} Currently, guidelines from the Council of Emergency Medicine Residency Directors consensus documents from 2009 and 2012 are a mainstay for residency education.^{26, 28} In addition, competency assessment tools for the evaluation of emergency medicine residents are being considered.²⁶

POINT-OF-CARE ULTRASONOGRAPHY IN PEDIATRIC EMERGENCY MEDICINE

More recently, pediatric emergency medicine (PEM) physicians have been using point-of-care US for patient care. According to a survey from 2011, 95% of EDs with a pediatric emergency medicine fellowship program utilize point-of-care US in some manner, and 88% of programs provide training in point-of-care US for their fellows.²⁹ This is a dramatic increase, as only 57% of programs reported the use of point-of-care US in 2006 and only 65% at that time incorporated training for their fellows.³⁰ Despite the growing use of point-of-care US by pediatric emergency physicians, there have been no published guidelines specific to pediatric emergency providers. The indications set forth in existing policy statements are written for emergency physicians who predominantly care for adult patients.

MINIMIZING RADIATION EXPOSURE

One of the appealing aspects of US is its inherent safety. It relies on sound waves and not x-rays to generate images. In many instances, computed tomography (CT) imaging or radiography are the optimal diagnostic modalities in the evaluation of the pediatric patient; however, there is an increasingly large body of literature emphasizing and delineating the risks of ionizing radiation, particularly from CT.³¹⁻⁴⁴ Pediatric patients are particularly sensitive to ionizing radiation, given the larger organ-specific dosing they receive with each study, the increased susceptibility of these organs to radiation-induced cancer, and the increased lifespan over which children may develop radiation-induced cancers.³⁴ In response to this risk, several national campaigns have been initiated to reduce the use of unnecessary CT imaging in pediatric patients. These include efforts by the Society for Pediatric Radiology,⁴⁵ the National Council on Radiation Protection and Measurements,⁴⁶ the Food and Drug Administration,⁴⁷ and the National Cancer Institute.⁴⁸ In summary, when imaging is indicated, practitioners should attempt to optimize the use of nonradiating diagnostic modalities, such as US.

INDICATIONS FOR POINT-OF-CARE ULTRASONOGRAPHY

Pediatric emergency medicine physicians can use point-of-care US as a diagnostic or procedural adjunct in the evaluation of patients in the ED. Diagnostic applications are those that assist in diagnosis and inform medical decision-making. Procedural applications may be “US-assisted” or “static,” or “US-guided,” also referred to as “dynamic.” Static US is defined as using US prior to the procedure, identifying anatomic structures, and determining the ideal circumstances for the procedure to be performed. The procedure itself is performed without the use of US. In contrast, in dynamic US, the US and procedure are performed simultaneously.

Clinical applications will be practice-specific and based on the patient population, incidence of disease, and the availability of resources, such as 24-hour attending radiologist coverage, availability of US technicians, and distance/transfer times to facilities that can provide US imaging. ED leaders should determine which point-of-care US examinations will be most useful to their practice environments. Physicians would then apply for institutional privileges in those specific areas. There will be a natural transition period for physicians who did not receive point-of-care US education as part of their graduate medical training. Therefore, the indications for which clinicians use point-of-care US will evolve over time as the education is disseminated throughout the PEM community. Finally, clinicians should be aware that point-of-care US is better used as a “rule-in” and not a “rule-out” diagnostic modality. The absence of an abnormal finding should not indicate a normal examination. For example, nonvisualization of an intussusception with high clinical concern must prompt further evaluation. Likewise, when findings other than those sought to “rule in” a diagnosis are encountered, a more complete imaging evaluation is warranted.

POINT-OF-CARE ULTRASONOGRAPHY TRAINING, CREDENTIALING, AND PRIVILEGING

Prior to implementing a program in the ED, departmental leaders should identify a core group of individuals with expertise in point-of-care US. This group is responsible for educating faculty and trainees as well as managing administrative tasks, such as outlining credentialing pathways and performing quality assurance image reviews. Standardized and universally accepted criteria for what designates a point-of-care expert are likely to evolve over time as advanced training programs are established. In departments or divisions without point-of-care US-trained individuals, departmental leadership should consider sending an individual or group of individuals with interest to receive additional training in point-of-care US. Alternatively, an expert from another department (eg, general emergency medicine, radiology) may assume these responsibilities and work collaboratively with ED leaders.

Point-of-care US training varies depending on the practitioner’s prior education and practice environment. Until now, most PEM physicians have received little or no point-of-care US instruction as part of their training. It is important that PEM fellowship programs provide adequate training including measurements of competency for trainees. Point-of-care US education is now an American Board of Pediatrics requirement for Pediatric Emergency Medicine fellowship programs.⁴⁹ Consensus education guidelines and a model curriculum were recently published.⁵⁰ There are 2 training pathways for physicians: a “training-based” pathway for current trainees, and a “practice-based” pathway for faculty without prior experience. The details of such pathways are outlined in the accompanying technical report.⁵¹

Prior to performing a point-of-care US examination for medical decision-making, PEM physicians must demonstrate application-specific competency. During this “training” phase, the point-of-care US expert should review all US examinations within a timely manner. Practitioners can receive relevant feedback regarding their examinations. In addition, novice practitioners should be supervised at the bedside in order to ensure that the examinations are being performed correctly. Examination reviews and bedside supervision may be performed by a department or division “expert” or by another physician already credentialed to perform US for that indication. These educational scans should not be utilized for medical decision-making and this should be clearly communicated to patients and their families.

Given that a point-of-care US examination is intended to be a focused examination, training requirements necessarily differ from those set forth by other specialty organizations, such as the American College of Radiology and other specialty organizations. A similar distinction was made in the 2002 training guidelines adopted by the American Society of Echocardiography, which outlined basic training requirements for anesthesiologists performing perioperative echocardiography, which differed from the more rigorous training needed for more consultative cardiology-performed echocardiography.⁵² Competency and subsequent credentialing within a division or department may be achieved after performing a specified number, or range, of accurately performed and interpreted point-of-care US examinations. With the lack of robust data supporting a specified number of examinations per indication, some guidelines suggest 25 to 50 examinations needed to achieve competency.²⁵ However, physicians should not interpret this recommendation as a “one-size-fits-all” approach, as examinations vary in difficulty and, therefore, may require more experience to establish competency. In addition, the number of examinations performed may not always best define competency. As point-of-care US incorporates both cognitive and psychomotor components, individual physicians may gain competency at varying rates that may be independent of a predetermined numerical goal and better assessed through simulation, observed structured clinical examinations, or direct observation during clinical shifts.

Hospital privileging committees should provide an opportunity for privileging in specific pediatric point-of-care US examinations. Written requirements for privileging should be delineated. Building on the recommendations set forth by the ACEP, when a physician applies for appointment or reappointment to the medical staff and for clinical privileges, the process should include assessment of current competency by the point-of-care US director.²⁵ Because point-of-care US is a relatively new technology for PEM physicians, some specialists and hospital privileging committees may not be familiar with the precedent already set forth for point-of-care US and the benefits to patient care. Therefore, PEM physicians should educate those who are unfamiliar with its use, citing the established literature attesting to emergency physicians’ ability to accurately perform and interpret point-of-care US examinations.^{5, 53-116} Additionally, emergency PEM physicians should consider collaboration with radiologists and expert sonographers when implementing point-of-care US into their ED.

POINT-OF-CARE ULTRASONOGRAPHY DOCUMENTATION

Once PEM physicians are credentialed to perform point-of-care US for a particular application, they can integrate the point-of-care US examination into patient care. Details of the point-of-care US examination must be documented at the time of performance in the medical record. Specifically, documentation should include the indication for the examination, structures/organs identified, and the interpretation.¹¹⁷ If the study is inadequate, this should also be noted. Images should be archived, ideally electronically, and entered as part of the electronic health record, for ease of retrieval and review.

RECOMMENDATIONS

1. Pediatric emergency medicine physicians should be familiar with the definition and application of point-of-care US and the utility for patients in the ED.
2. Pediatric emergency physicians who integrate point-of-care US in their patient care should be competent in point-of-care examinations that are specific and relevant to their clinical environment.
3. For EDs with a pediatric emergency medicine point-of-care US program, there must be a process in place for educating and assessing practitioner skill, maintaining quality assurance, and acquiring and maintaining hospital privileges.
4. Pediatric emergency medicine fellowship programs should have a structured point-of-care US education curriculum and competency assessment for fellows in training.

SUMMARY

There is an increasing demand for PEM physicians to become adept in point-of-care US. Mounting evidence supports the benefits to pediatric patients. This policy statement and accompanying technical

report have been developed to define a structured and safe program for the integration and implementation of point-of-care US by PEM physicians.

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The guidance in this statement does not indicate an exclusive course of treatment or serve as a standard of medical care. Variations, taking into account individual circumstances, may be appropriate.

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References:

1. Howard ZD, Noble VE, Marill KA, et al. Bedside Ultrasound Maximizes Patient Satisfaction. *JEM*. 2013;1–8. doi:10.1016/j.jemermed.2013.05.044.
2. Jones AE, Tayal VS, Sullivan DM, Kline JA. Randomized, controlled trial of immediate versus delayed goal-directed ultrasound to identify the cause of nontraumatic hypotension in emergency department patients*. *Critical Care medicine*. 2004;32(8):1703–1708. doi:10.1097/01.CCM.0000133017.34137.82.
3. Kirkpatrick AW, Sirois M, Ball CG, et al. The hand-held ultrasound examination for penetrating abdominal trauma. *The American Journal of Surgery*. 2004;187(5):660–665. doi:10.1016/j.amjsurg.2004.02.003.
4. Liteplo AS, Marill KA, Villen T, et al. Emergency Thoracic Ultrasound in the Differentiation of the Etiology of Shortness of Breath (ETUDES): Sonographic B-lines and N-terminal Pro-brain-type Natriuretic Peptide in Diagnosing Congestive Heart Failure. *Academic Emergency Medicine*. 2009;16(3):201–210. doi:10.1111/j.1553-2712.2008.00347.x.
5. Melniker LA, Leibner E, McKenney MG, Lopez P, Briggs WM, Mancuso CA. Randomized controlled clinical trial of point-of-care, limited ultrasonography for trauma in the emergency department: the first sonography outcomes assessment program trial. *Ann Emerg Med*. 2006;48(3):227–235. doi:10.1016/j.annemergmed.2006.01.008.
6. Moore CL, Copel JA. Point-of-care ultrasonography. *N Engl J Med*. 2011;364(8):749–757. doi:10.1056/NEJMra0909487.
7. ACR-ACOG-AIUM Practice Guideline for the Performance of Obstetrical Ultrasound. *acrorg*. 2007;1–9. Available at: http://www.acr.org/~media/ACR/Documents/PGTS/guidelines/US_Obstetrical.pdf. Accessed January 27, 2012.

8. Quiñones MA, Douglas PS, Foster E, et al. ACC/AHA clinical competence statement on echocardiography. *Journal of the American College of Cardiology*. 2003;41(4):687–708. doi:10.1016/S0735-1097(02)02885-1.
9. Blaivas M, Lyon M. The effect of ultrasound guidance on the perceived difficulty of emergency nurse-obtained peripheral IV access. *J Emerg Med*. 2006;31(4):407–410. doi:10.1016/j.jemermed.2006.04.014.
10. Brannam L, Blaivas M, Lyon M, Flake M. Emergency Nurses' Utilization of Ultrasound Guidance for Placement of Peripheral Intravenous Lines in Difficult-access Patients. *Acad Emerg Med*. 2004;11(12):1361–1363. doi:10.1197/j.aem.2004.08.027.
11. Chin EJ, MD CHC, BS RM, et al. A Pilot Study Examining the Viability of a Prehospital Assessment with UltraSound for Emergencies (PAUSE) Protocol. *J Emerg Med*. 2012:1–8. doi:10.1016/j.jemermed.2012.02.032.
12. Heegaard W, Hildebrandt D, Spear D, Chason K, Nelson B, Ho J. Prehospital Ultrasound by Paramedics: Results of Field Trial. *Academic Emergency Medicine*. 2010;17(6):624–630. doi:10.1111/j.1553-2712.2010.00755.x.
13. Henderson A, Andrich DE, Pietrasik ME, Higgins D, Montgomery B, Langley SEM. Outcome analysis and patient satisfaction following octant transrectal ultrasound-guided prostate biopsy: a prospective study comparing consultant urologist, specialist registrar and nurse practitioner in urology. *Prostate Cancer Prostatic Dis*. 2004;7(2):122–125. doi:10.1038/sj.pcan.4500696.
14. Henderson SO, Ahern T, Williams D, Mailhot T, Mandavia D. Emergency department ultrasound by nurse practitioners. *Journal of the American Academy of Nurse Practitioners*. 2010;22(7):352–355. doi:10.1111/j.1745-7599.2010.00518.x.
15. Iregui MG, Prentice D, Sherman G, Schallom L, Sona C, Kollef MH. Physicians' estimates of cardiac index and intravascular volume based on clinical assessment versus transesophageal Doppler measurements obtained by critical care nurses. *Am J Crit Care*. 2003;12(4):336–342.
16. Noble VE, Lamhaut L, Capp R, et al. Evaluation of a thoracic ultrasound training module for the detection of pneumothorax and pulmonary edema by prehospital physician care providers. *BMC Med Educ*. 2009;9(1):3. doi:10.1186/1472-6920-9-3.
17. Walcher F, Weinlich M, Conrad G, et al. Prehospital ultrasound imaging improves management of abdominal trauma. *Br J Surg*. 2006;93(2):238–242. doi:10.1002/bjs.5213.
18. American College of Emergency Physicians: Council Resolution on Ultrasound. ACEP News, November 1990.
19. Society for Academic Emergency Medicine. Ultrasound Position Statement. SAEM Newsletter Summer 1991.
20. Hall M, DD P, Heller M, et al. Model curriculum for physician training in emergency ultrasonography. *Ann Emerg Med*. 1994;23(1):95–102.
21. American Medical Association. House of Delegates Meeting 1999, Resolution 802, I-99.
22. American Medical Association policy H-230.960. Privileging for ultrasound imaging. Available at:

<http://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0CB4QFjAA&url=http%3A%2F%2Fwww.acep.org%2FWorkArea%2FDownloadAsset.aspx%3Fid%3D44304&ei=Hsv8U7jPI86VyAS2-YDQDw&usq=AFQjCNHO4-dCf2RLkdR8B0kGmj-UF9zhRQ&bvm=bv.73612305,d.aWw>. Accessed August 26, 2014.

23. Hockberger RS, Binder LS, Graber MA, et al. The model of the clinical practice of emergency medicine. *Ann Emerg Med.* 2001;37(6):745–770. doi:10.1067/mem.2001.115495.
24. American College of Emergency Physicians. American College of Emergency Physicians. ACEP emergency ultrasound guidelines-2001. *Ann Emerg Med.* 2001;38(4):470–481.
25. ACEP policy statement: Emergency ultrasound guidelines. *Ann Emerg Med.* 2009;53(4):550–570. doi:10.1016/j.annemergmed.2008.12.013.
26. Akhtar S, Theodoro D, Gaspari R, et al. Resident training in emergency ultrasound: consensus recommendations from the 2008 Council of Emergency Medicine Residency Directors Conference. In: Vol 16 Suppl 2. 2009:S32–6. doi:10.1111/j.1553-2712.2009.00589.x.
27. AIUM officially recognizes ACEP emergency ultrasound guidelines. Available at: www.aium.org/soundWaves/article.aspx?aId=442&iId=20111117. Accessed October 19, 2012.
28. Lewiss RE, Pearl M, Nomura JT, et al. CORD-AEUS: Consensus Document for the Emergency Ultrasound Milestone Project. Burton J, ed. *Acad Emerg Med.* 2013;20(7):740–745. doi:10.1111/acem.12164.
29. Marin JR, Zuckerbraun NS, Kahn JM. Use of emergency ultrasound in United States pediatric emergency medicine fellowship programs in 2011. *Journal of Ultrasound in medicine : official journal of the American Institute of Ultrasound in Medicine.* 2012;31(9):1357–1363.
30. Ramirez-Schrempp D, Dorfman DH, Tien I, Liteplo AS. Bedside ultrasound in pediatric emergency medicine fellowship programs in the United States: little formal training. *Pediatr Emerg Care.* 2008;24(10):664–667. doi:10.1097/PEC.0b013e3181884955.
31. Pearce MS, Salotti JA, Little MP, et al. Radiation exposure from CT scans in childhood and subsequent risk of leukaemia and brain tumours: a retrospective cohort study. *The Lancet.* 2012;499–505. doi:10.1016/S0140-6736(12)60815-0.
32. Brenner DJ, Hall EJ. Computed tomography--an increasing source of radiation exposure. *N Engl J Med.* 2007;357(22):2277–2284. doi:10.1056/NEJMra072149.
33. Brenner D, Elliston C, Hall E, Berdon W. Estimated risks of radiation-induced fatal cancer from pediatric CT. *AJR Am J Roentgenol.* 2001;176(2):289–296.
34. Brenner DJ. Estimating cancer risks from pediatric CT: going from the qualitative to the quantitative. *Pediatr Radiol.* 2002;32(4):228–231. doi:10.1007/s00247-002-0671-1.
35. Brody AS, Frush DP, Huda W, Brent RL, American Academy of Pediatrics Section on Radiology. Radiation risk to children from computed tomography. *Pediatrics.* 2007;120(3):677–682. doi:10.1542/peds.2007-1910.
36. Callahan MJ. CT dose reduction in practice. *Pediatr Radiol.* 2011;41 Suppl 2:488–492. doi:10.1007/s00247-011-2099-y.

37. Donnelly LF. Reducing radiation dose associated with pediatric CT by decreasing unnecessary examinations. *AJR Am J Roentgenol.* 2005;184(2):655–657.
38. Fazel R, Krumholz HM, Wang Y, et al. Exposure to low-dose ionizing radiation from medical imaging procedures. *N Engl J Med.* 2009;361(9):849–857. doi:10.1056/NEJMoa0901249.
39. Fenton SJ, Hansen KW, Meyers RL, et al. CT scan and the pediatric trauma patient--are we overdoing it? *J Pediatr Surg.* 2004;39(12):1877–1881.
40. Frush DP, Donnelly LF, Rosen NS. Computed tomography and radiation risks: what pediatric health care providers should know. *Pediatrics.* 2003;112(4):951–957.
41. Hartin CW Jr, Jordan JM, Gemme S, et al. Computed tomography scanning in pediatric trauma: opportunities for performance improvement and radiation safety. *J Surg Res.* 2013;180(2):226–231. doi:10.1016/j.jss.2012.04.020.
42. Nickoloff EL, Alderson PO. Radiation exposures to patients from CT: reality, public perception, and policy. *AJR Am J Roentgenol.* 2001;177(2):285–287.
43. Rajaraman P, Simpson J, Neta G, et al. Early life exposure to diagnostic radiation and ultrasound scans and risk of childhood cancer: case-control study. *BMJ (Clinical research ed).* 2011;342:d472.
44. Linet MS, Kim K-P, Rajaraman P. Children’s exposure to diagnostic medical radiation and cancer risk: epidemiologic and dosimetric considerations. *Pediatr Radiol.* 2008;39(S1):4–26. doi:10.1007/s00247-008-1026-3.
45. Slovis TL. Conference on the ALARA (as low as reasonably achievable) concept in pediatric CT: intelligent dose reduction. *Pediatr Radiol.* 2002;32:217-8.
46. Linton OW, Mettler FA, National Council on Radiation Protection and Measurements. National conference on dose reduction in CT, with an emphasis on pediatric patients. *AJR Am J Roentgenol.* 2003;181(2):321–329.
47. Food and Drug Administration. FDA public health notification: reducing radiation risk from computed tomography for pediatric and small adult patients. *Pediatr Radiol.* 2002;32(4):314–316. doi:10.1007/s00247-002-0687-6.
48. National Cancer Institute. Radiation risks and pediatric computed tomography (CT): A guide for health care providers. Available at <http://cancer.gov/cancerinfo/causes/radiation-risks-pediatric-ct>. Accessed October 26, 2011.
49. American Board of Pediatrics Content Outline: Pediatric Emergency Medicine. 2009:1–147.
50. Vieira RL, Hsu D, Nagler J, Chen L, Gallagher R, Levy JA. Pediatric Emergency Medicine Fellow Training in Ultrasound: Consensus Educational Guidelines. Moore C, ed. *Academic Emergency Medicine.* 2013;20(3):300–306. doi:10.1111/acem.12087.
51. Marin JR, Lewiss RE; American Academy of Pediatrics, Society of Academic Emergency Medicine, American College of Emergency Physicians, World Interactive Network Focused on Critical Ultrasound. Technical report: point-of-care ultrasonography by pediatric emergency medicine physicians. *Pediatrics.* In press

52. Cahalan MK, Stewart W, Pearlman A, et al. American Society of Echocardiography and Society of Cardiovascular Anesthesiologists task force guidelines for training in perioperative echocardiography. *2002;15(6):647–652. doi:10.1067/mje.2002.123956.*
53. Fox JC, Boysen M, Gharahbaghian L, et al. Test characteristics of focused assessment of sonography for trauma for clinically significant abdominal free fluid in pediatric blunt abdominal trauma. *Acad Emerg Med.* 2011;18(5):477–482. doi:10.1111/j.1553-2712.2011.01071.x.
54. Holmes JF, Gladman A, Chang CH. Performance of abdominal ultrasonography in pediatric blunt trauma patients: a meta-analysis. *J Pediatr Surg.* 2007;42(9):1588–1594. doi:10.1016/j.jpedsurg.2007.04.023.
55. Sola JE, Cheung MC, Yang R, et al. Pediatric FAST and elevated liver transaminases: An effective screening tool in blunt abdominal trauma. *J Surg Res.* 2009;157(1):103–107. doi:10.1016/j.jss.2009.03.058.
56. Squire BT, Fox JC, Anderson C. ABCESS: applied bedside sonography for convenient evaluation of superficial soft tissue infections. *Acad Emerg Med.* 2005;12(7):601–606. doi:10.1197/j.aem.2005.01.016.
57. Tayal VS, Hasan N, Norton HJ, Tomaszewski CA. The Effect of Soft-tissue Ultrasound on the Management of Cellulitis in the Emergency Department. *Academic Emergency Medicine.* 2006;13(4):384–388. doi:10.1197/j.aem.2005.11.074.
58. Sivitz AB, Lam SHF, Ramirez-Schrempp D, Valente JH, Nagdev AD. Effect of bedside ultrasound on management of pediatric soft-tissue infection. *Journal of Emergency Medicine.* 2010;39(5):637–643. doi:10.1016/j.jemermed.2009.05.013.
59. Iverson K, Haritos D, Thomas R, Kannikeswaran N. The effect of bedside ultrasound on diagnosis and management of soft tissue infections in a pediatric ED. *American Journal of Emergency Medicine.* 2012;30(8):1347–1351. doi:10.1016/j.ajem.2011.09.020.
60. Marin JR, J DA, Bilker WB, Panebianco NL, Brown NJ, Alpern ER. Emergency Ultrasound-assisted Examination of Skin and Soft Tissue Infections in the Pediatric Emergency Department. Moore C, ed. *Acad Emerg Med.* 2013;20(6):545–553. doi:10.1111/acem.12148.
61. Friedman DI, Forti RJ, Wall SP, Crain EF. The utility of bedside ultrasound and patient perception in detecting soft tissue foreign bodies in children. *Pediatr Emerg Care.* 2005;21(8):487–492.
62. Chen L, Hsiao AL, Moore CL, Dziura JD, Santucci KA. Utility of bedside bladder ultrasound before urethral catheterization in young children. *Pediatrics.* 2005;115(1):108–111. doi:10.1542/peds.2004-0738.
63. Witt M, Baumann BM, McCans K. Bladder ultrasound increases catheterization success in pediatric patients. *Acad Emerg Med.* 2005;12(4):371–374. doi:10.1197/j.aem.2004.11.023.
64. Randazzo MR, Snoey ER, Levitt MA. Accuracy of emergency physician assessment of left ventricular ejection fraction and central venous pressure using echocardiography. *Academic Emergency Medicine.* 2003;10(9):973–977.
65. Pershad J, Myers S, Plouman C, et al. Bedside limited echocardiography by the emergency physician is accurate during evaluation of the critically ill patient. *Pediatrics.* 2004;114(6):e667–71.

doi:10.1542/peds.2004-0881.

66. Longjohn M, Wan J, Joshi V, Pershad J. Point-of-Care Echocardiography by Pediatric Emergency Physicians. *Pediatr Emerg Care*. 2011;27(8):693–696. doi:10.1097/PEC.0b013e318226c7c7.
67. Chen L, Hsiao A, Langhan M, Riera A, Santucci KA. Use of bedside ultrasound to assess degree of dehydration in children with gastroenteritis. *Acad Emerg Med*. 2010;17(10):1042–1047. doi:10.1111/j.1553-2712.2010.00873.x.
68. Chen L, Kim Y, Santucci KA. Use of ultrasound measurement of the inferior vena cava diameter as an objective tool in the assessment of children with clinical dehydration. *Acad Emerg Med*. 2007;14(10):841–845. doi:10.1197/j.aem.2007.06.040.
69. Perera P, Mailhot T, Riley D, Mandavia D. The RUSH exam: Rapid Ultrasound in SHock in the evaluation of the critically ill. *Emerg Med Clin North Am*. 2010;28(1):29–56, vii. doi:10.1016/j.emc.2009.09.010.
70. Labovitz AJ, Noble VE, Bierig M, et al. Focused cardiac ultrasound in the emergent setting: a consensus statement of the American Society of Echocardiography and American College of Emergency Physicians. In: Vol 23. 2010:1225–1230. doi:10.1016/j.echo.2010.10.005.
71. Kendall JL, Shimp RJ. Performance and interpretation of limited right upper quadrant ultrasound by emergency physicians. *J Emerg Med*. 1998;21(1):7–13.
72. Blaivas M, Harwood RA, Lambert MJ. Decreasing length of stay with emergency ultrasound examination of the gallbladder. *Academic Emergency Medicine*. 1999;6(10):1020–1023.
73. Freeman K, Dewitz A, Baker WE. Ultrasound-guided hip arthrocentesis in the ED. *Am J Emerg Med*. 2007;25(1):80–86. doi:10.1016/j.ajem.2006.08.002.
74. LaRocco BG, Zlupko G, Sierzenski P. Ultrasound diagnosis of quadriceps tendon rupture. *J Emerg Med*. 2008;35(3):293–295. doi:10.1016/j.jemermed.2007.05.015.
75. Sisson C, Nagdev A, Tirado A, Murphy M, Suner S. Ultrasound diagnosis of traumatic partial triceps tendon tear in the emergency department. *JEM*. 2011;40(4):436–438. doi:10.1016/j.jemermed.2008.03.047.
76. Weinberg ER, Tunik MG, Tsung JW. Accuracy of clinician-performed point-of-care ultrasound for the diagnosis of fractures in children and young adults. *Injury*. 2010;41(8):862–868. doi:10.1016/j.injury.2010.04.020.
77. Durston W, Swartzentruber R. Ultrasound guided reduction of pediatric forearm fractures in the ED. *Am J Emerg Med*. 2000;18(1):72–77.
78. Patel DD, Blumberg SM, Crain EF. The utility of bedside ultrasonography in identifying fractures and guiding fracture reduction in children. *Pediatr Emerg Care*. 2009;25(4):221–225.
79. Chen L, Kim Y, Moore CL. Diagnosis and guided reduction of forearm fractures in children using bedside ultrasound. *Pediatr Emerg Care*. 2007;23(8):528–531. doi:10.1097/PEC.0b013e318128f85d.
80. Cross KP, Warkentine FH, Kim IK, Gracely E, Paul RI. Bedside ultrasound diagnosis of clavicle

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- fractures in the pediatric emergency department. *Acad Emerg Med.* 2010;17(7):687–693. doi:10.1111/j.1553-2712.2010.00788.x.
81. Chien M, Bulloch B, Garcia-Filion P, Youssfi M, Shrader MW, Segal LS. Bedside ultrasound in the diagnosis of pediatric clavicle fractures. *Pediatr Emerg Care.* 2011;27(11):1038–1041. doi:10.1097/PEC.0b013e318235e965.
 82. Chaar-Alvarez FM, Warkentine F, Cross K, Herr S, Paul RI. Bedside ultrasound diagnosis of nonangulated distal forearm fractures in the pediatric emergency department. *Pediatr Emerg Care.* 2011;27(11):1027–1032. doi:10.1097/PEC.0b013e318235e228.
 83. Ramirez-Schrempp D, Vinci RJ, Liteplo AS. Bedside ultrasound in the diagnosis of skull fractures in the pediatric emergency department. *Pediatr Emerg Care.* 2011;27(4):312–314. doi:10.1097/PEC.0b013e3182131579.
 84. Rabiner JE, Friedman LM, Khine H, Avner JR, Tsung JW. Accuracy of Point-of-Care Ultrasound for Diagnosis of Skull Fractures in Children. *Pediatrics.* 2013;131(6):1757–1764. doi:10.1542/peds.2012-3921.
 85. Vieira RL, Levy JA. Bedside ultrasonography to identify hip effusions in pediatric patients. *Ann Emerg Med.* 2010;55(3):284–289. doi:10.1016/j.annemergmed.2009.06.527.
 86. Shah VP, Tunik MG, Tsung JW. Prospective Evaluation of Point-of-Care Ultrasonography for the Diagnosis of Pneumonia in Children and Young Adults. *JAMA Pediatr.* 2013;167(2):119–125. doi:10.1001/2013.jamapediatrics.107.
 87. Theodoro D, Blaivas M, Duggal S. Real-time B-mode ultrasound in the ED saves time the diagnosis of deep vein thrombosis (DVT). *Am J Emerg Med.* 2004;22(3):197–200.
 88. Magazzini S, Vanni S, Toccafondi S. Duplex ultrasound in the emergency department for the diagnostic management of clinically suspected deep vein thrombosis. *Academic Emergency Medicine.* 2007;14(3):216–220.
 89. Jolly BT, Massarin E, Pigman EC. Color Doppler ultrasonography by emergency physicians for the diagnosis of acute deep venous thrombosis. *Academic Emergency Medicine.* 1997;4(2):129–132.
 90. Blaivas M, Theodoro D, Sierzenski PR. A study of bedside ocular ultrasonography in the emergency department. *Acad Emerg Med.* 2002;9(8):791–799.
 91. Tayal VS, Neulander M, Norton HJ, Foster T, Saunders T, Blaivas M. Emergency department sonographic measurement of optic nerve sheath diameter to detect findings of increased intracranial pressure in adult head injury patients. *Ann Emerg Med.* 2007;49(4):508–514. doi:10.1016/j.annemergmed.2006.06.040.
 92. Yoonessi R, Hussain A, Jang TB. Bedside ocular ultrasound for the detection of retinal detachment in the emergency department. *Acad Emerg Med.* 2010;17(9):913–917. doi:10.1111/j.1553-2712.2010.00809.x.
 93. Riera A, Hsiao AL, Langhan ML, Goodman TR, Chen L. Diagnosis of intussusception by physician novice sonographers in the emergency department. *Ann Emerg Med.* 2012;60(3):264–268. doi:10.1016/j.annemergmed.2012.02.007.

94. Sivitz AB, Tejani C, Cohen SG. Evaluation of Hypertrophic Pyloric Stenosis by Pediatric Emergency Physician Sonography. Gorelick MH, ed. *Acad Emerg Med*. 2013;n/a–n/a. doi:10.1111/acem.12163.
95. Fox JC, Solley M, Anderson CL, Zlidenny A, Lahham S, Maasumi K. Prospective evaluation of emergency physician performed bedside ultrasound to detect acute appendicitis. *Eur J Emerg Med*. 2008;15(2):80–85. doi:10.1097/MEJ.0b013e328270361a.
96. McRae A, Edmonds M, Murray H. Diagnostic accuracy and clinical utility of emergency department targeted ultrasonography in the evaluation of first-trimester pelvic pain and bleeding: a systematic review. *CJEM*. 2009;11(4):355–364.
97. Blaivas M, Sierzenski P, Plecque D. Do emergency physicians save time when locating a live intrauterine pregnancy with bedside ultrasonography? *Academic Emergency Medicine*. 2000;7(9):988–993.
98. Stein JC, Wang R, Adler N. Emergency physician ultrasonography for evaluating patients at risk for ectopic pregnancy. *Ann Emerg Med*. 2010;56:674–683.
99. Randolph AG, Cook DJ, Gonzales CA, Pribble CG. Ultrasound guidance for placement of central venous catheters: a meta-analysis of the literature. *Critical Care medicine*. 1996;24(12):2053–2058.
100. Miller AH, Roth BA, Mills TJ, Woody JR, Longmoor CE, Foster B. Ultrasound guidance versus the landmark technique for the placement of central venous catheters in the emergency department. *Acad Emerg Med*. 2002;9(8):800–805.
101. Keyes LE FBSEEA. Ultrasound-Guided Brachial and Basilic Vein Cannulation in Emergency Department Patients With Difficult Intravenous Access. *Ann Emerg Med*. 1999;34:711–714.
102. Doniger SJ, Ishimine P, Fox JC, Kanegaye JT. Randomized controlled trial of ultrasound-guided peripheral intravenous catheter placement versus traditional techniques in difficult-access pediatric patients. *Pediatr Emerg Care*. 2009;25(3):154–159. doi:10.1097/PEC.0b013e31819a8946.
103. Ferre RM, Sweeney TW. Emergency physicians can easily obtain ultrasound images of anatomical landmarks relevant to lumbar puncture. *American Journal of Emergency Medicine*. 2007;25(3):291–296. doi:10.1016/j.ajem.2006.08.013.
104. Nomura JT, Leech SJ, Shenbagamurthi S, et al. A randomized controlled trial of ultrasound-assisted lumbar puncture. *Journal of Ultrasound in medicine : official journal of the American Institute of Ultrasound in Medicine*. 2007;26(10):1341–1348.
105. Liebmann O, Price D, Mills C, et al. Feasibility of forearm ultrasonography-guided nerve blocks of the radial, ulnar, and median nerves for hand procedures in the emergency department. *Ann Emerg Med*. 2006;48(5):558–562. doi:10.1016/j.annemergmed.2006.04.014.
106. Stone MB, Wang R, Price DD. Ultrasound-guided supraclavicular brachial plexus nerve block vs procedural sedation for the treatment of upper extremity emergencies. *Am J Emerg Med*. 2008;26(6):706–710. doi:10.1016/j.ajem.2007.09.011.
107. Shiver S, Blaivas M, Lyon M. A Prospective Comparison of Ultrasound-guided and Blindly Placed Radial Arterial Catheters. *Academic Emergency Medicine*. 2006;13(12):1275–1279. doi:10.1197/j.aem.2006.07.015.

108. D P, Brunette D, Asinger R, Ruiz E. Emergency department echocardiography improves outcome in penetrating cardiac injury. *Ann Emerg Med.* 1992;21(6):709–712.
109. Gaspari RJ. Emergency Ultrasound and Urinalysis in the Evaluation of Flank Pain. *Acad Emerg Med.* 2005;12(12):1180–1184. doi:10.1197/j.aem.2005.06.023.
110. Watkins S, Bowra J, Sharma P, Holdgate A, Giles A, Campbell L. Validation of emergency physician ultrasound in diagnosing hydronephrosis in ureteric colic. *Emergency Medicine Australasia.* 2007;19(3):188–195. doi:10.1111/j.1742-6723.2007.00925.x.
111. Burnside PR, Brown MD, Kline JA. Systematic Review of Emergency Physician–performed Ultrasonography for Lower-Extremity Deep Vein Thrombosis. *Academic Emergency Medicine.* 2008;15(6):493–498. doi:10.1111/j.1553-2712.2008.00101.x.
112. Adhikari S, Blaivas M, Lyon M. Diagnosis and management of ectopic pregnancy using bedside transvaginal ultrasonography in the ED: a 2-year experience. *Am J Emerg Med.* 2007;25(6):591–596. doi:10.1016/j.ajem.2006.11.020.
113. Adhikari S, Blaivas M, Lyon M. Role of Bedside Transvaginal Ultrasonography in the Diagnosis of Tubo-ovarian Abscess in the Emergency Department. *J Emerg Med.* 2008;34(4):429–433. doi:10.1016/j.jemermed.2007.05.057.
114. Blaivas M, Sierzenski P, Lambert M. Emergency evaluation of patients presenting with acute scrotum using bedside ultrasonography. *Acad Emerg Med.* 2001;8(1):90–93.
115. Nazeer SR, Dewbre H, Miller AH. Ultrasound-assisted paracentesis performed by emergency physicians vs the traditional technique: a prospective, randomized study. *Am J Emerg Med.* 2005;23(3):363–367. doi:10.1016/j.ajem.2004.11.001.
116. Wiler JL, Costantino TG, Filippone L, Satz W. Ultrasound in Emergency Medicine. *JEM.* 2010;39(1):76–82. doi:10.1016/j.jemermed.2008.05.012.
117. Resnick J, Hoffenberg S, Tayal V, Dickman E. Ultrasound coding and reimbursement update 2009. Emergency Ultrasound Section. American College of Emergency Physicians. Available at: <http://www.acep.org/content.aspx?id=32182>. Accessed March 26, 2013.